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Immediate improvements of supination range of motion and strength following pronator teres muscle friction massage: a clinical trial comparing people with and without supination limited motion

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ABSTRACT

Objectives: To investigate the effects of friction massage techniques on the pronator teres muscle on supination range of motion (ROM) and supinator strength in individuals with and without limited supination ROM.

Methods: In total, 26 subjects (13 with limited supination ROM and 13 healthy subjects) volunteered to participate in this study. We used a customized wrist cuff. Supination ROM and supinator strength were measured with a 9-axis inertial motion sensor and load cell. The friction massage protocol was executed with the pronator teres muscle in a relaxed position. Then supination ROM and supinator strength were measured again.

Results: There was no significant interaction effect on supination ROM, which was significantly greater in the limited supination and control groups. A post hoc *t*-test revealed that the limited supination group achieved a significantly increased post-test supination ROM (51.7 ± 7.8°) compared to the pre-test value (43.6 ± 5.2°). In addition, the control group achieved a significant increase in post-test supination ROM (67.7 ± 10.0°) compared to the pre-test value (61.4 ± 7.7°). There was no significant interaction effect on supinator strength. Supinator strength was significantly greater in the limited supination and control groups. A post hoc *t*-test revealed a significant difference in supinator strength between the pre- and post-test values in the limited supination group.

Discussion: Friction massage helps restore a limited ROM of the forearm supination motion and immediately increases supinator muscle strength. This technique can be used as an intervention method to improve muscle strength in patients with limited supination ROM.

KEYWORDS
Biceps brachii; forearm movement; friction massage; pronator teres; pronator syndrome; soft tissue; supination range of motion; supinator strength

1. Introduction

The proximal and distal radio-ulnar joints allow forearm pronation and supination movements [1]. Several studies have suggested that a continuous pronated forearm position or repeated pronation movements can lead to musculoskeletal disorders. For example, white-collar workers who are mainly engaged in typing on a computer spend the majority of their time with their forearm in a pronated position [2,3]. For workers assembling factory products, excessive use of the pronator teres muscle can occur when loosening screws with the right hand or tightening screws with the left hand. Excessive use of the pronator teres muscle can also occur in the process of connecting parts to parts [4,5]. Persistence of such a position or repeated movements may lead to pain, shortened pronator muscles, and neuropathic issues due to compression of the median and/or anterior interosseous nerves [6–8].

Some interventions are used to alleviate symptoms related to pronation injuries including surgery, medication, electrical stimulation, and hyperthermia. In particular, supination strengthening exercises are generally performed in which subjects hold a weighted object and perform supination of the forearm alone or with elbow flexion [9–11]. However, surgical methods do not help relieve nerve compression in the pronator teres, and conservative treatment should be given priority [12]. Furthermore, exercises to strengthen the supinator muscles can cause excessive stress on these muscles and symptoms such as tennis elbow or even muscle injury [13–16].

Alternative interventions have also been proposed, including stretching the pronator muscles to improve the mobility of the fascia, alleviating symptoms through neural mobilization, massaging the soft tissue, applying deep pressure to the trigger point of the pronator teres muscle, and using friction massage (FM) [11,17,18]. FM was introduced by James Cyriax in 1980 [19]. It was the first manual technique proposed to solve tendon-related disorders [19]. It is effective at alleviating pain and relieving the symptoms of tendinopathy [20–22]. Its effects on tendons include traumatic hyperemia, increased blood flow to

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tissues, removal of soft tissue adhesions, and stimulation of mechanical receptors [19,20,22,23].

However, no studies have examined the use of FM of the pronator teres muscle or relaxation techniques on individuals with limited supination range of motion (SROM). Moreover, no studies have analyzed the effects of FM on SROM or the strength of supinator muscles. Therefore, we investigated the effects of FM on supination strength (SS) and SROM after FM of the pronator teres muscle. We hypothesized that FM on the pronator teres muscle would increase the SROM and increase SS.

2. Methods

2.1. Subjects

In total, 26 subjects (15 male and 11 female) volunteered to participate in this study. Subjects were recruited by verbal or posted announcement from the university. All subjects were informed of the purpose of the study and its possible risks. The subjects confirmed their consent to participate by completing a research consent form. No participants had a history of rheumatologic, orthopedic, or neurological disorders or trauma or surgery to the shoulder or elbow region. All subjects received an explanation of this study and agreed to participate in this study by signing a consent form. This study was approved by the Yonsei University Wonju Institutional Review Board (approval number:1041849-201803-BM-023-03).

The participants were divided into groups with and without limited SROM. The normal SROM is 90–100°, and the SROM for functional tasks is 50°; thus, patients with a forearm SROM of less than 50° were assigned to the limited SROM group, and patients with a forearm supination of more than 50° were assigned to the control group [24]. During the study, the subjects refrained from strenuous exercise and excessive stretching. Subject demographics are shown in Table 1.

2.2. Instrumentation

2.2.1. Customized prosthesis and the smart KEMA system

We used a customized wrist cuff designed to measure SROM and SS to avoid the involvement of wrist muscles during supination motion (Figure 1). The wrist cuff has a metal rod located parallel to the distal radioulnar joint. SROM and SS were measured using the Smart KEMA system (Koreatech Inc., Seoul, Korea). A nine-axis inertial motion sensor and load cell were used.

Figure 1. Customized wrist cuff.

Table 1. Subject characteristics (n = 26).

Variable	Limited SROM [a] group	Control group	*p* value
Age (years)	21.8 ± 1.3[c]	22.5 ± 1.7	.307
Height (cm)	167.6 ± 7.8	172.5 ± 6.0	.116
Weight (kg)	66.5 ± 10.2	72.7 ± 14.6	.252
BMI [b] (kg/m^2)	23.6 ± 2.3	24.3 ± 3.7	.570

[a]Limited supination range of motion
[b]Body mass index
[c]Mean ± standard deviation

2.2.2. Electromyography (EMG)

The muscle activity of the biceps brachii (BB) during the SS test was measured to assess whether variation in SS was due to the difference in muscle activity of the BB, one of the supinator muscles, before and after applying FM. BB muscle activity was measured using the TeleMyo 2400T (Noraxon USA, Inc., Scottsdale, AZ, USA) and analyzed using MyoResearch software (XP Master Edition 1.07; Noraxon USA, Inc.). Before attaching the EMG electrodes, the skin was shaved and gently rubbed with sandpaper to reduce impedance. One surface electrode was applied to the biceps parallel to the muscle fibers, two-thirds of the distance between the shoulder and elbow [25]. Correct electrode placement was verified through observation of the oscilloscope during resisted elbow flexion. Maximal voluntary isometric contraction (MVIC) was used to normalize the EMG data.

2.3. Procedure

Prior to data collection, subjects were familiarized with the testing protocol, received instructions, and practiced the exercises to ensure proper motion. Participants maintained an upright posture in a sitting position on a chair. In an elbow-extended position, the head of the radius is moved to the narrower, distal part of radio-ulnar joint, and volar-dorsal translation occurs less. To avoid excessive joint accessory motion, the subjects were measured for SS and SROM when the shoulder was flexed at 90° and the elbow joint was fully extended. The subjects then performed a supination motion. The customized wrist cuff was connected to the Smart KEMA strength sensor, which was attached to a grounded vacuum lifter for SS measurement (Figure 2). To measure SROM, the Smart KEMA motion sensor was placed on a metal bar connected to a customized prosthesis (Figure 3). The examiner fixed the elbow joint to prevent external rotation of the participant's shoulder during supination motion and to prevent elbow joint flexion. This trial was repeated three times, and the results of SROM were calculated as the mean. As in measuring SS, the shoulder joint was flexed at 90° in the sitting position and the elbow joint was fully extended. A metal bar connected to the customized wrist cuff was linked to the Smart KEMA system based on the load cell and fixed to the floor. The examiner fixed the elbow joint so that the participant's shoulder did not rotate externally, and isometric contraction strength of supinator was measured. SS and BB EMG data were collected simultaneously. The duration of each trial was 5 s, and mean values for SS and BB EMG data were calculated from the middle 3 s. An intra-class correlation coefficient (ICC) [1,3] model and 95% confidence intervals (CIs) were used to evaluate the intra-session reliability of the SROM measurement. SROM demonstrated excellent intra-session reliability (ICC [1,3] = 0.98, 95% CI: 0.963–0.992), and intra-session reliability was also good for the SS measurement (ICC [1,3] = 0.91, 95% CI: 0.811–0.958).

Figure 2. SS (Supination strength) measurement.

Figure 3. SROM (Supination range of motion) measurement.

To perform FM, the participants were seated in a chair with the elbow flexed at 90° on a therapeutic table. The subject maintained the forearm in the most comfortable position possible so that the pronator teres muscle fibers could remain loose. The pronator teres muscle is a superficial muscle located between the flexor carpi radialis and brachioradialis on the anterior surface of the forearm. The practitioner used a thumb to apply friction massage to the pronator teres muscle fibers. The pressure was deep enough to move the tissue, firmly held by the practitioner, back and forth; the pressure was regulated according to the patient's tolerance. The FM was performed in five periods of 3 min each. During the FM, the subject's pain was recorded following each period and the pressure was increased as tolerated so to affect the pronator teres deep tissue [26].

2.4. Data collection

Data collected using the Smart KEMA system were transmitted to a tablet PC (Galaxy tab A 6 10.1, Samsung Inc., Seoul, Korea) via the Bluetooth device connection and Smart KEMA application software (Koreatech Inc., Seoul, Korea). The collected SS data were normalized to body weight. Normalized strength is represented as the percentage of body weight (%BW = [maximal strength of each trial (kg)/body weight (kg)] × 100) [27]. The average normalized strength was calculated for subsequent analyses. All EMG data are presented as the percentage of MVIC. To collect MVIC data, subjects performed MVIC of the biceps muscle based on the muscle manual testing position [28]. To examine the BB, subjects sat on a chair with a backrest to fix the trunk and performed elbow flexion at 90° with the forearm in a neutral position. Manual resistance was applied to the distal part of the forearm and wrist. Subjects repeated MVIC three times with a 30-s rest between each trial to obtain the mean EMG value, which was set as 100% MVIC. Subjects maintained each trial for 5 s with a 30 s rest between muscle contraction. The average value of the middle 3 s of the 5 s period was used for data analyses; the EMG signals were amplified and the sampling rate was 1000 Hz. A bandpass filter between 20 and 450 Hz was used and a notch filter at 60 Hz was applied. EMG data were processed into root-mean-square values, calculated from 50 ms data points.

2.5. Statistical analyses

SPSS version 24.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analyses. A 2 × 2 mixed analysis of variance (ANOVA) was used to identify significant differences in SROM, SS, and BB EMG between groups (limited SROM vs. control; between factors) and within groups (pre- vs. post-test). The level of significance was set to 0.05. A post hoc *t*-test was used to assess differences between pre- and post-test values.

3. Results

3.1. ROM

There was no significant interaction effect on SROM ($F_{1,12}$ = 0.388, $p > 0.05$). SROM significantly increased after FM in the limited SROM and control groups ($p < 0.001$). A post hoc *t*-test revealed a significant increase in the post-test SROM value in the limited SROM group compared to the pre-test value ($p < 0.05$). The control group also exhibited a significant increase in the post-test SROM value compared to the pre-test value ($p < 0.05$) (Table 2).

3.2. Strength

There was no significant interaction effect on SS ($F_{1,12}$ = 3.689, $p > 0.0.5$). SS significantly increased in the limited SROM and control groups after FM ($p < 0.05$). A post hoc *t*-test revealed a significant difference in SS between pre- and post-test values in the limited SROM group ($p < 0.05$) but not in controls ($p > 0.05$) (Table 2).

3.3. EMG

There was no interaction effect on BB EMG ($F_{1,12}$ = 0.002, $p > 0.05$). There were no significant differences in BB EMG between groups ($F_{1,12}$ = 2.419, $p > 0.05$) (Table 2).

4. Discussion

We investigated the effects of FM of the pronator teres muscle on SROM and SS in subjects with and without limited SROM. Both groups showed a significant increase in SROM after FM (8.1 ± 6.5° in the limited SROM group; 6.3 ± 8.2° in the control group). SS increased significantly by 1.0 ± 1.1 kg in the limited SROM group after FM, whereas the control group showed no significant difference (mean increase of 0.2 ± 1.1 kg) after FM. The BB EMG did not show a significant difference in either group.

Previous studies of FM have mainly been conducted on athletes or healthy subjects and have examined the effects of FM after a particular exercise or sports activity [29–32]. For this reason, previous studies have mainly focused on large muscles of the lower extremities such as the quadriceps or hamstrings [30,31]. Several studies have shown that the ROM of joints increases after FM. Crosman et al. (1984) showed that FM of the hamstrings led to an immediate, significant increase in the knee joint extension angle and leg raise angle. In addition, Bell and Jada [33], who applied FM to patients with chronic low back pain, reported a significant increase in lower extremity ROM. However, other studies have reported no improvement or even negative effects after FM [32,34].

In our study, there was a significant increase in the ROM of the elbow joint after FM, which is consistent with previous studies [35,36]. Muscle strength also improved, which differs from previous FM studies [30,32]. There are several possible reasons for this. First, previous studies have shown that when FM is applied to a specific muscle, the range of motion of the related joint increases [37]. Furthermore, the results of this study showed that FM of the pronator muscle increased SROM. This may be not only because FM increased SROM directly but also because FM increased the length of the BB muscle and thereby increased SS. Second, participants held a position that may have suppressed the actions of other synergistic muscles. The supination movement was performed with the elbow in an extended position such that BB length could not produce maximal force [38]. BB can produce the greatest force when the angle of elbow flexion is between 90 and 120° [38]. BB strength decreases gradually as the elbow moves farther away from this angle [38]. When the elbow is at a 90° angle, SS is greatest, whereas SS decreases as the elbow approaches 0° due to the contribution of BB to the supination movement [39].

Table 2. Comparison of BB EMG, SROM, and SS between the limited SROM and control groups.

	Limited SROM [a] group Mean (SD [b])		Control group Mean (SD)		ANOVA p value		
	Pre-	Post-	Pre-	Post-	Group	Time	Group[g] Time
BB[c] EMG (% MVIC)	22.5 (17.0)	28.2 (14.6)	25.2 (19.2)	30.6 (22.1)	0.682	0.133	0.966
SROM[d] (°)	43.6 (5.2)	51.7[h] (7.8)	61.4 (7.7)	67.7[h] (10.0)	0.000[g]	0.000[g]	0.539
SS[e] (% BW[f])	2.7 (1.3)	3.6[h] (1.3)	3.6 (0.9)	3.7 (1.0)	0.216	0.013[g]	0.067

[a]Supination limited range of motion
[b]Standard deviation
[c]Biceps brachii
[d]Supination range of motion
[e]Supinator muscle strength
[f] Body weight
[g]Significant differences identified by ANOVA ($p < 0.05$)
[h] Significant differences identified by the post hoc *t*-test ($p < 0.05$)

This study has some limitations. First, the subjects were normal individuals who were not patients with pain or diseases. FM is applied to soft tissues such as muscles, ligaments, and tendons to prevent adhesion of tissues and promote blood circulation to improve symptoms. It is difficult to generalize our results to those with pain in the elbow or those with diseases such as pronator syndrome. Second, it is difficult to generalize our results to all ages because our study targeted young men and women. Therefore, further studies should be conducted on patients of various ages with elbow or wrist symptoms.

5. Conclusions

This study showed that the SROM and SS increased immediately after pronator teres FM. Therefore, FM can help to increase limited ROM and immediately increase muscle strength. Particularly, it can be used as an intervention to improve SS in patients with limited SROM.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

[1] Neumann DA. Kinesiology of the musculoskeletal system: foundations for rehabilitation. St Louis (MO): Mosby. Elsevier; 2010.
[2] Hünting W, Grandjean TLE. Postural and visual loads at VDT workplaces I. Constrained postures. Ergonomics. 1981;24(12):917–931.
[3] Sauter SL, Schleifer LM, Knutson SJ. Work posture, workstation design, and musculoskeletal discomfort in a VDT data entry task. Hum Factors. 1991;33(2):151–167.
[4] Grevsten S, Sjögren B. Symptoms and sickleave among forestry machine operators working with pronated hands. Appl Ergon. 1996;27(4):277–280.
[5] Rempel DM, Harrison RJ, Barnhart S. Work-related cumulative trauma disorders of the upper extremity. JAMA. 1992;267(6):838–842.
[6] Lee J-T, Azari K, Jones NF. Long term results of radial tunnel release–the effect of co-existing tennis elbow, multiple compression syndromes and workers' compensation. J Plastic, Reconstr Aesthetic Surg. 2008;61(9):1095–1099.
[7] Magee DJ. Orthopedic physical assessment. St Louis (MO): Saunders Elsevier; 2002.
[8] Viikari-Juntura E. Neck and upper limb disorders among slaughterhouse workers: an epidemiologic and clinical study. Scand J Work Environ Health. 1983;283–290.
[9] Magee DJ, Zachazewski JE, Quillen WS, et al. Pathology and intervention in musculoskeletal rehabilitation. Vol. 3, Philadelphia (PA): Elsevier Health Sciences; 2015.
[10] Higgins M. Therapeutic exercise: from theory to practice. Philadelphia (PA): FA Davis; 2011.
[11] Houglum PA. Therapeutic exercise for musculoskeletal injuries. 4th ed. Champaign (IL): Human Kinetics; 2016.
[12] Hartz CR, Linscheid R, Gramse R, et al. The pronator teres syndrome: compressive neuropathy of the median nerve. J Bone Joint Surg Am. 1981;63(6):885–890.
[13] Noteboom T, Cruver R, Keller J, et al. Tennis elbow: a review. J Orthopaedic Sports Phys Ther. 1994;19(6):357–366.
[14] Verhaar J. Tennis elbow. Int Orthop. 1994;18(5):263–267.
[15] Mueller MJ, Maluf KS. Tissue adaptation to physical stress: a proposed "Physical Stress Theory" to guide physical therapist practice, education, and research. Phys Ther. 2002;82(4):383–403.
[16] Rettig AC. Elbow, forearm and wrist injuries in the athlete. Sports Med. 1998;25(2):115–130.
[17] Sanderson M. Soft tissue release: a practical handbook for physical therapists. Chichester (WS): Lotus Pub; 2012.
[18] Skirven TM, Osterman AL, Fedorczyk J, et al. Rehabilitation of the hand and upper extremity, 2-volume set E-book: expert consult. Philadelphia (PA): Elsevier Health Sciences; 2011.
[19] Cyriax JH, Russell G. Treatment by manipulation, massage and injection. Vol. 2. Bailliere Tindall; 1980.
[20] Chamberlain GJ. Cyriax's friction massage: a review. J Orthopaedic Sports Phys Ther. 1982;4(1):16–22.
[21] Cyriax JH, Cyriax P. Cyriax's illustrated manual of orthopaedic medicine. Philadelphia (PA): Elsevier Health Sciences; 1996.
[22] Schwellnus M, Mackintosh L, Mee J. Deep transverse frictions in the treatment of lliotibial band friction syndrome in athletes: a clinical trial. Physiotherapy. 1992;78(8):564–568.
[23] Joseph MF, Taft K, Moskwa M, et al. Deep friction massage to treat tendinopathy: a systematic review of a classic treatment in the face of a new paradigm of understanding. J Sport Rehabil. 2012;21(4):343–353.
[24] LaStayo PC, Lee MJ. The forearm complex: anatomy, biomechanics and clinical considerations. J Hand Ther. 2006;19(2):137–145.
[25] Cram JR. Cram's introduction to surface electromyography. Sudbury (MA): Jones & Bartlett Learning; 2011.
[26] Hertling D, Kessler RM. Management of common musculoskeletal disorders: physical therapy principles and methods. Philadelphia (PA): Lippincott Williams & Wilkins; 2006.
[27] Forthomme B, Croisier J-L, Foidart-Dessalle M, et al. Isokinetic assessment of the forearm and wrist muscles. Isokinetics Exerc Sci. 2002;10(3):121–128.
[28] Kendall FP, McCreary EK, Provance P. Muscles, testing and function. Braille Jymico Incorporated; 1995.
[29] Crosman LJ, Chateauvert SR, Weisberg J. The effects of massage to the hamstring muscle group on range of motion. J Orthopaedic Sports Phys Ther. 1984;6(3):168–172.
[30] Dawson LG, Dawson KA, Tiidus PM. Evaluating the influence of massage on leg strength, swelling, and pain following a half-marathon. J Sports Sci Med. 2004;3(YISI 1):37.
[31] Moraska A, Chandler C, Edmiston-Schaetzel A, et al. Comparison of a targeted and general massage protocol on strength, function, and symptoms associated with carpal tunnel syndrome: a randomized pilot study. J Altern Complement Med. 2008;14(3):259–267.

[32] Wiktorsson-Moller M, Öberg B, Ekstrand J, et al. Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. Am J Sports Med. 1983;11(4):249–252.
[33] Bell J. Massage therapy helps to increase range of motion, decrease pain and assist in healing a client with low back pain and sciatica symptoms. J Bodyw Mov Ther. 2008;12(3):281–289.
[34] Barlow A, Clarke R, Johnson N, et al. Effect of massage of the hamstring muscle group on performance of the sit and reach test. Br J Sports Med. 2004;38(3):349–351.
[35] Cheatham SW, Kolber MJ, Cain M, et al. The effects of self-myofascial release using a foam roll or roller massager on joint range of motion, muscle recovery, and performance: a systematic review. Int J Sports Phys Ther. 2015;10(6):827.
[36] Halperin I, Aboodarda SJ, Button DC, et al. Roller massager improves range of motion of plantar flexor muscles without subsequent decreases in force parameters. Int J Sports Phys Ther. 2014;9(1):92.
[37] Hassan SM, Hafez AR, Seif HE, et al. The effect of deep friction massage versus stretching of wrist extensor muscles in the treatment of patients with tennis elbow. Open J Ther Rehabil. 2016;4(01):48.
[38] PETROFsKY JS, Phillips CA. The effect of elbow angle on the isometric strength and endurance of the elbow flexors in men and women. J Hum Ergol (Tokyo). 1980;9(2):125–131.
[39] O'sullivan LW, Gallwey TJ. Upper-limb surface electro-myography at maximum supination and pronation torques: the effect of elbow and forearm angle. J Electromyogr Kinesiol. 2002;12(4):275–285.